Energy Levels in Coupled Quantum-Wells and the Possible Application in QWIP

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Quantum well infrared photodetector (QWIP) employed III-V compound semiconductors such as AlGaAs/GaAs and GaAs/InGaAs are undergoing rapid development. QWIP devices offer significant producibility advantages over the second-generation HgCdTe photodiodes for affordable large area focal plane arrays (FPA's) for long wavelength infrared (LWIR, 7.8-10 μ m) and multi-spectral application. Basically, the difference between quantum well IR photodetetors and most of the other photodetectors is the type of electronic transition that creates electron-hole pairs. In a QWIP, the process involves an intersubbnad transition where the absorbed IR radiation excites electrons bound in the quantum well into the continuum of states. Here we treat the more general case of bound-to-bound transitions in coupled quantum wells, including electric bias.

Fig. 1 shows the transition energies of E1, E2 and (E2-E1), calculated from the associated coupled quantum well as a function of barrier height in the center of well. The thickness of the central barrier is 10 A. It is found that the ground state E1 is nearly proportional to the barrier height while the excited state E2 is almost unchanged. The behavior is the same as that previously reported and is a result of the ground-state wave function having a maximum in the center of the well while the excited state has a minimum. To further investigate the effects of the thickness of central barrier on the transition energies, we refer to Fig. 2 where the thickness is in the range of 6 to 15 A. We find that the wider the thickness is, the upper the ground state is. These results suggest additional design freedom to adjust the energy levels by inserting another barrier in the center of well.

In this presentation, we also develop multiple stair-like potential barriers to calculate electrical modulation of the coupled quantum well. Due to the symmetry of the coupled quantum well, the electric-field shifts of the intersubbnad energy levels are small, as shown in Fig.3.

Since the coupled quantum well, as stated above, having two energy states in the well has additional freedom in designing the new QWIP's, we demonstrate another coupled quantum well where two thin barriers are introduced in the well. The primarily calculated results are shown in Fig.4. Further detailed results including electric field modulation, various asymmetrical coupled quantum well with its applications to QWIPs will also be reported here.

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REFERENCES

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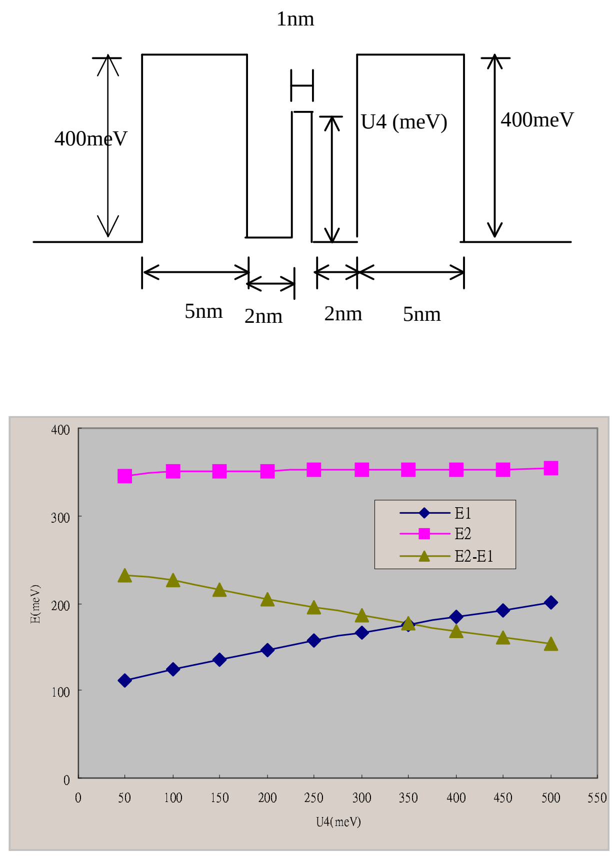


Fig. 1: the transition energies of E1, E2 and (E2-E1) where the thickness of the central barrier is 10 A.

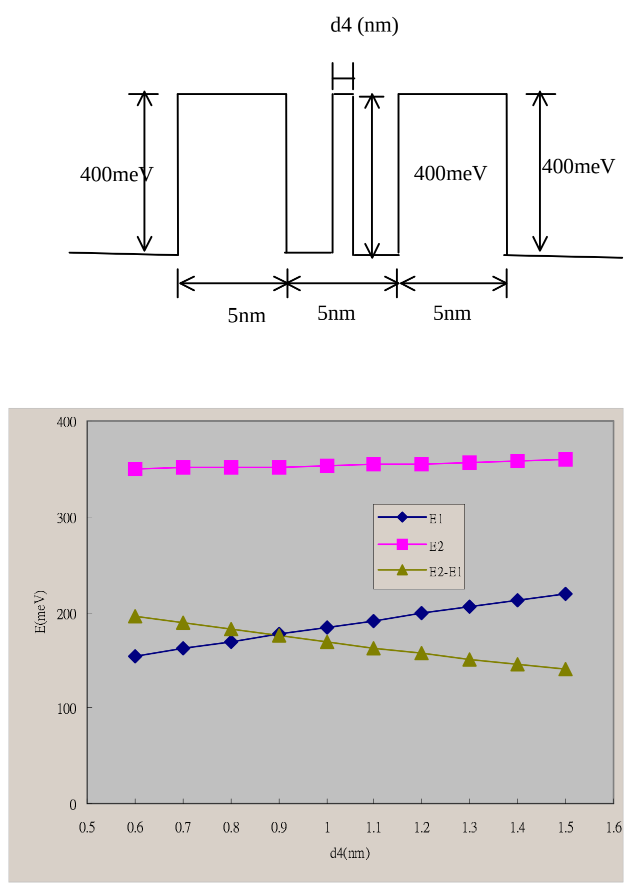
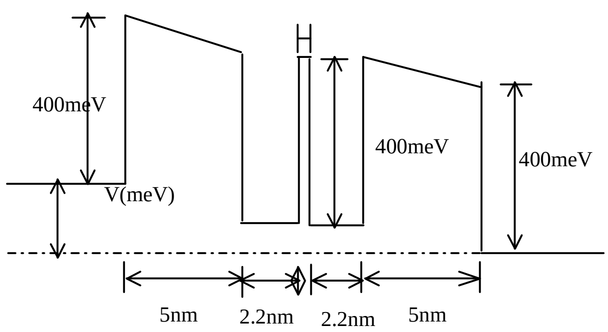


Fig. 2: the transition energies of E1, E2 and (E2-E1) where the thickness is in the range of 6 to 15 A.



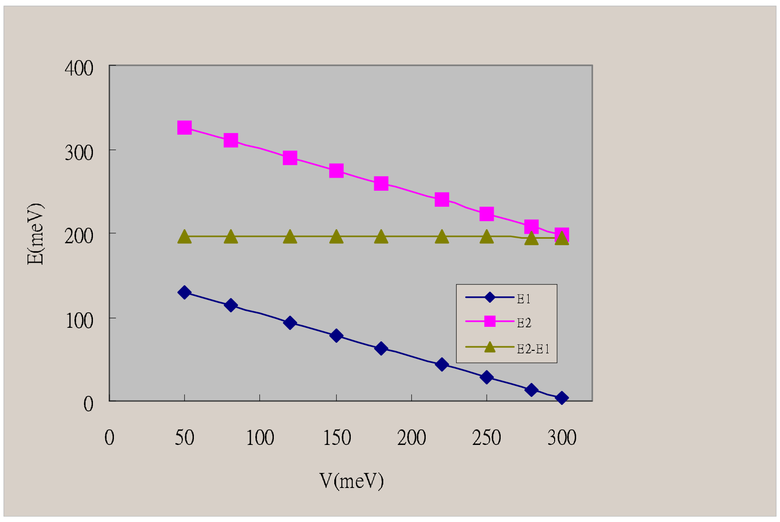
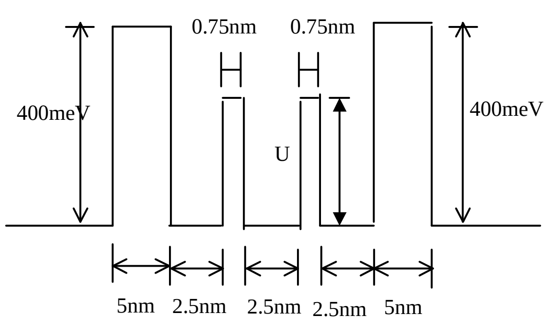


Fig. 3: the transition energies of E1, E2 and (E2-E1) where the electric-field shifts of the intersubbnad energy levels are small.



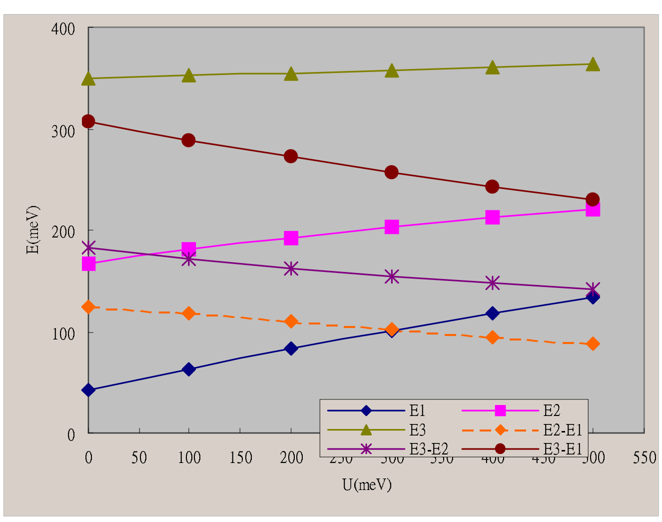


Fig. 4: the transition energies where two thin barriers are introduced in the well.